Counterfeit Electronic Components Detection Possibilities

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Abstract: - The counterfeit electronic components detection methods are mainly aimed at characteristic features which are relatively difficult to copy in original quality and accuracy. Electric parametric tests in various complexities are very efficient in revealing discrepancies. The curve tracing methods are reasonably simple and accessible. At our workplace, we deal with electronic components V-I characteristic analysis performed on components samples gained directly from the industrial area in frames of our cooperation with companies producing electronic modules. We have a counterfeit detector with a sophisticated concept of V-I characteristic measurement and comparison at our disposal. We are collecting data on various component types and component production technologies.

Key-Words: - counterfeit component, counterfeit detector, V-I characteristic, scan mode, component pin print

1 Introduction

We can meet counterfeit products on various complexity levels and in various commodities. The counterfeited products in electronics apply not only to complex products by reputable brands, like satellite receivers, mobile phones, navigation units etc. The counterfeit dirty business has penetrated even in the field of electronic components. We can encounter counterfeited clones of precise and stable resistors, capacitors, transistors, and integrated circuits of various complexities. The counterfeit components invasion in supply chains is threatening not only the quality and reliability of consumer electronics, but even all sensitive electronic systems in the medicine, industrial control systems, weapon system, civil and military aviation, space research systems and many others.

The counterfeit components penetration in product assemblies is facilitated with several factors. A very important role plays component accessibility and costs. The pressure for cost reduction favours interesting price offers both at modern components scarce because of production launching phase, and also at obsolete components because of long life equipment maintenance reasons.

There are many counterfeit electronic component variants. The empty package with pins and like original marking on one side, and very elaborated counterfeit component versions almost undistinguishable from the original at which reliability, lifetime, and temperature range is deteriorated from various reasons. Such sort of counterfeit components is very difficult to be discovered only with immediate measurement and analysis. Such components should be exposed to the long term tests in statistical sets, and under conditions accelerating manifestation of differences.

The tests for originality could be sorted in two main groups, non-destructive and destructive testing methods. The destructive methods call for special equipment, for instance for de-capsulation, to make it possible to compare the chip and package marking. Non-destructive methods span from costly analytical equipment, like micro focus X-ray systems, and ultrasound microscopy, to relatively simple and widely affordable equipment for marking analysis and simple electrical tests. There is the original component sample for comparison purposes recommended in most cases.

Those simple to use and cost effective means could be very helpful in the preliminary suspect components identification and sorting. The visual and simple optical methods can serve for component marking structural and quality analysis including the producer logo originality, package surface evidences for black topping, pins finishing, shape and dimensions differences, etc. The accompanying documentation analysis is also very important to be performed. The visual analysis combined with approachable electrical parameters inspection represents an effective tool set applicable even outside the specialized centres.

2 V-I characteristics tracing method

The V-I characteristics tracing method is not new. It displays graphically the relation between the current flowing through a pair of component pins and the defined voltage waveform applied to them. Dipole components V-I characteristics are well known, like resistors, capacitors and diodes. As an example, there is an illustration of triac V-I characteristic in Fig.1.

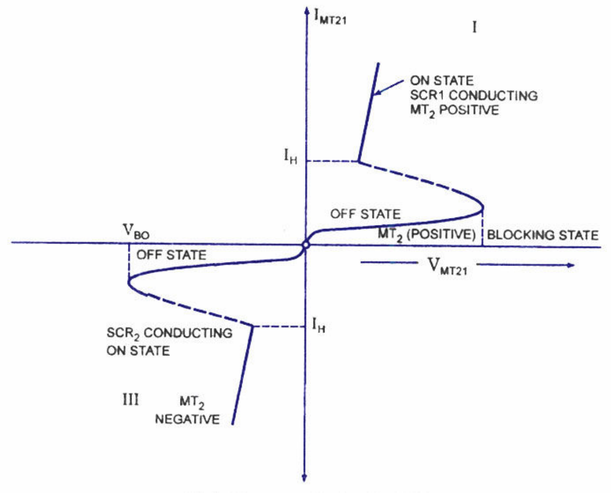

Fig.1 V-I Characteristic of a Triac [7]

The expression (1) represents a common relation between the current I flowing through two pins of a component and an applied voltage waveform V_W (sinus, triangle, ramp) swept in set limits, for instance ±10 Volts peak-to-peak.

$$I = f\left(V_W\right) \qquad (1)$$

The expression (2) represents a static relation for a diode p-n junction model, and expression (3) is its dynamic variant, where i_D is a time dependent current through the junction, V_D is the applied time dependent voltage, q is the carrier charge, n is the electron density, k is the Boltzman´s constant, and T is the junction temperature in absolute scale.

$$I = I_0\left(e^{\frac{qV}{nkT}} - 1\right) \qquad (2)$$

$$i_D\left(t\right) = I_0\left(e^{\frac{qV_D(t)}{nkT}} - 1\right) \qquad (3)$$

The diagnostic method based on the dual channel comparison of dipoles configurations is called Analogue Signature Analysis, and it has also its history so far. Fig.2 illustrates an example of faulty V-I characteristic deformation (the right curve) of pin 1 referenced to pin 9 (ground pin) at the HT46R47 integrated circuit measured at our place.

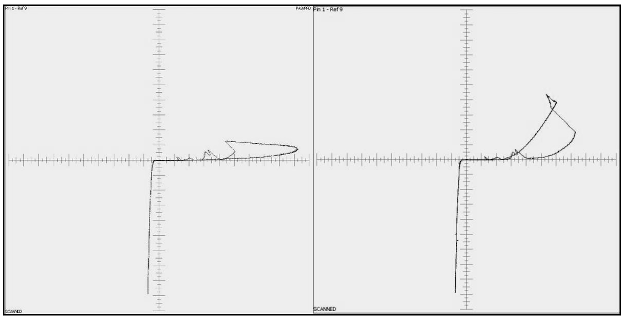

Fig.2 Analogue signature of a good and faulty pin

A degree and shape of V-I characteristic deformation influenced by failures, or by differences related to various origins can serve as criterion not only for failure classification, but also for dissimilarities arising from derivative way of component processing. The measurement devices technological development has facilitated new designs in the area of multichannel counterfeit component detectors. There is a choice among several measurement modes, applied voltage waveforms and parameters. We are analysing various component samples with the help of Sentry Counterfeit IC Detector by ABI Electronics, Ltd. from Great Britain. That device has 256 channels, and it is possible to use it with a proper component package contact adapter for any component with pin count less than 256. Components with lower pin count can be tested in parallel. The pin print of the original component can be saved in the application program memory, and the pin prints of analysed components can be compared to it without the original component presence.

3 Component sample analysis

We have received several component sample groups directly from industrial area for analysis. We would like to present some results concerning MOSFET transistor component type as an illustration of the curve tracing method possibilities. We have analysed two sample groups. The group ***A*** hold one original Cool MOS transistor with enhanced N channel, and 3 transistors of the same type, but of a different origin. The group ***B*** holds 5 MOSFET Fast diode SuperMESH transistors with enhanced N channel where no original was specified, just the random mix of them.

We can choose either Normal mode or Matrix mode for analysis. In the Normal mode, each component pin is referred to the reference pin (ground pin V_{ss} is recommended) set in the preparatory process in advance. In the Matrix mode, each pin is successively combined with all other pins to create a couple for curve tracing analysis. The choice between Normal mode and Matrix mode depends on component type and its production technology. The basic criterion for mode choice is always the V-I characteristic sensitivity to compared components differences. That sensitivity can differ according to the component type and to the production technology so that no mode is generally preferred in advance at the very beginning. Both modes application is comparable at typical dipole components like resistors, capacitors or diodes, and we can only distinguish the polarity of measurement signal onset if it is important for the analysis. The measurement signal has three optional waveforms, namely sinus, triangle, and ramp. The signal frequency is also adjustable in steps starting from 100 Hz to 5 kHz. The source resistance is adjustable in steps from 1 kOhm to 100 kOhm.

The transistor analysis in Normal mode asks for a choice of the best reference pin to get the highest sensitivity to differences between compared samples. Such selective tests we performed at the analysis beginning. An example of group ***A*** master transistor V-I characteristics acquired in Matrix mode are illustrated in the Fig.3.

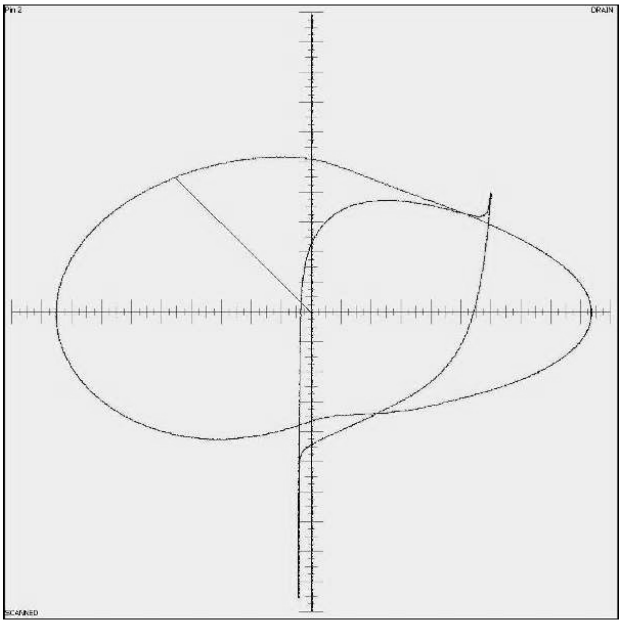

Fig.3 Master V-I Characteristics in Matrix Mode, Example for Pin 2 in Reference to Other Pins

The group ***A*** suspect transistor Matrix mode comparison result is illustrated in the Fig.4. The criterion for comparison identity is based on the compared V-I characteristics dots percentage in the tolerance range area and outside it. Our examples were tested with the 3% horizontal and vertical range. Our measurement applied the sinus signal with peak voltage amplitude ±10 Volts, frequency of 100 Hz and source resistance of 100 kΩ.

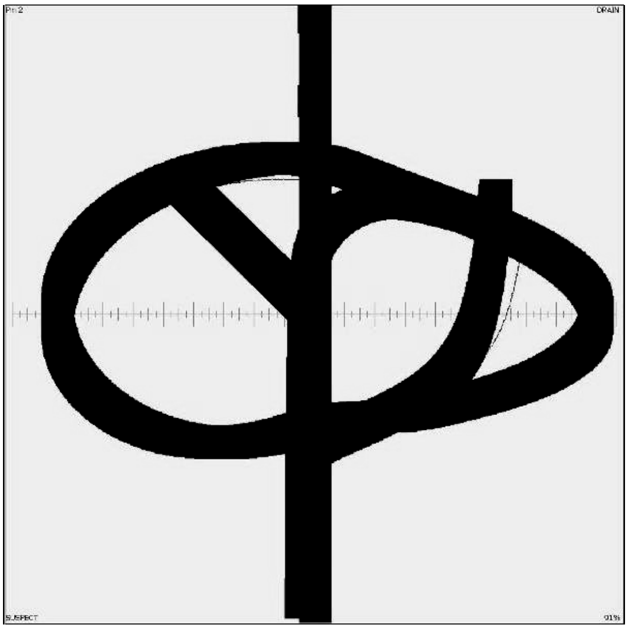

Fig.4 Comparison Result in Matrix Mode, Example for Suspect Sample, Pin 2

The illustrative master transistor pin 2 (Drain) V-I characteristic in Normal mode referenced to pin 3 (Source) is in the Fig.5.

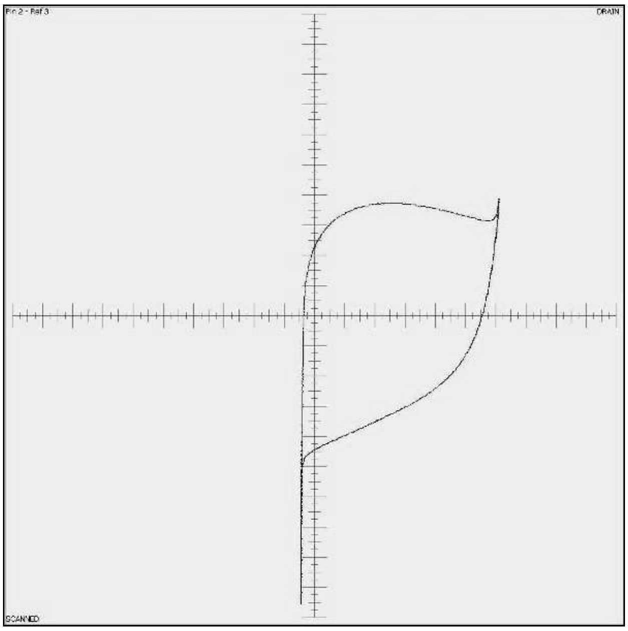

Fig.5 Master V-I Characteristic in Normal Mode, Example for Pin 2 (Drain), Reference Pin 3 - Source

The pin 2 (Drain) referenced to pin 3 (Source) comparison result of the same suspect sample transistor (group ***A***) in Normal mode is displayed in Fig.6. As it was already mentioned above, the evaluation criterion for sample comparison is the ratio between V-I curve dots number in the tolerance field to all dots creating the V-I curve. There is a range of other evaluation algorithm applicable for such analysis. Nevertheless, this method is less sensitive to production variations cause by the technology itself.

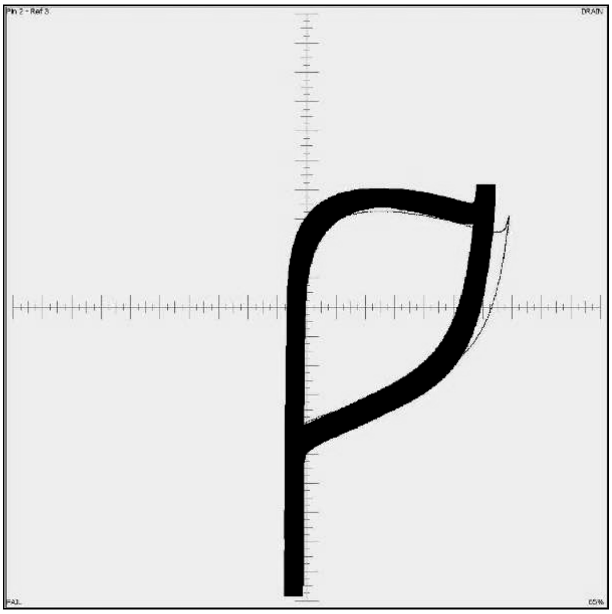

Fig.6 Comparison Result in Normal Mode, Example for Suspect Sample, Pin 2

Table 1 represents a results overview example for the whole group analysed. The corresponding numbers express the percentage of comparison identity with master component tolerance range set in advance. The comparison criteria for pin and component evaluation are as follows:
Horizontal Tolerance: 3%, Vertical Tolerance: 3%, Pin Fail Tolerance: 75%, Pin Suspect Tolerance: 95%, Fail if Fails Tolerance: 5%, Fail if Suspects Tolerance: 15%, Suspect if Fails Tolerance: 3%, Suspect if Suspect Tolerance: 10%

Power MOSFET Transistor Group 1				
Sample	NORMAL MODE Ref – 3 (Source)			Result
	Pin1	Pin2	Pin3	
M	100	100	100	Ref
1	49	65	100	fail
2	48	83	100	fail
3	52	75	100	fail

Table1 Analysis Overview in Normal Mode, Reference Pin - Source

4 Conclusion

Our paper indicates some examples of possible electronic counterfeit components testing for originality based on V-I characteristics tracing. The analysis results of that sample group ***B*** mentioned only briefly has shown the clear difference between groups with different marking and lot coding. The evaluated differences could be influenced not only with fake production reasons but also with improper component treatment, like electrostatic discharge exposure or excessive thermal exposure during component processing. The test methodology, and test conditions is not fixed in advance but in opposite, it is created step by step with collecting experience and necessary data for individual components types and manufacturing technologies.

ACKNOWLEDGMENTS

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